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Appendix F:

Space Systems -- Work Breakdown Structure and Definitions

F.1 -- Scope

This appendix provides the space system work breakdown structure. Definitions for the launch vehicle; the orbital transfer vehicle; the space vehicle; and for ground command, control, communications and mission equipment; flight support operations and services; and storage are provided in this appendix. Definitions for WBS elements common to the space system and all other defense materiel items are in Appendix H: Work Breakdown Structure Definitions, Common Elements.

F.2 -- Work Breakdown Structure Levels

Level 1	Level 2	Level 3
Space System	Launch Vehicle	Propulsion (Single Stage Only) Stage I Stage II..n (As Required) Strap-On Units (As Required) Shroud (Payload Fairing) Guidance and Control Integration, Assembly, Test and Checkout
	Orbital Transfer Vehicle	Propulsion (Single Stage Only) Stage I Stage II..n (As Required) Strap-On Units (As Required) Guidance and Control Integration, Assembly, Test and Checkout
	Space Vehicle	Spacecraft Payload I..n (As Required) Reentry Vehicle Orbit Injector/Dispenser Integration, Assembly, Test and Checkout
	Ground Command, Control, Communications and Mission Equipment	Sensor I..n (As Required) Telemetry, Tracking and Control External Communications

	Data Processing Equipment Launch Equipment Auxiliary Equipment
Flight Support Operations and Services	Mate/Checkout/Launch Mission Control Tracking and C^3 Recovery Operations and Services Launch Site Maintenance/Refurbishment
Storage	Planning and Preparation Storage Transfer and Transportation
Systems Engineering/ Program Management	
System Test and Evaluation	Development Test and Evaluation Operational Test and Evaluation Mock-ups Test and Evaluation Support
Training	Equipment Services Facilities
Data	Technical Publications Engineering Data Management Data Support Data Data Depository
Peculiar Support Equipment	Test and Measurement Equipment Support and Handling Equipment
Common Support Equipment	Test and Measurement Equipment Support and Handling Equipment
Operational/Site Activation	System Assembly, Installation and Checkout on Site Contractor Technical Support Site Construction Site/Ship/Vehicle Conversion

Industrial Facilities	Construction/Conversion/Expansion Equipment Acquisition or Modernization Maintenance (Industrial Facilities)
Initial Spares and Repair Parts	

F.3 -- Definitions

F.3.1 -- Space System

The complex of equipment (hardware/software), data, services, and facilities required to attain and/or maintain an operational capability in space. This operational capability requires the ability to develop, deliver, and maintain mission payload(s) in specific orbit, which further requires the ability to place, operate, and recover manned and unmanned space systems.

Includes:

- launch vehicles, orbital transfer vehicles, shrouds, space vehicles, communications, command and control facilities and equipment, and any mission equipment or other items necessary to provide an operational capability in space.

F.3.2 -- Launch Vehicle

The primary means for providing initial thrust to place a space vehicle into its operational environment. The launch vehicle is the prime propulsion portion of the complete flyaway (not to include the orbital transfer vehicle and space vehicle). The launch vehicle may be single-stage or multiple-stage configuration.

Includes:

- the structure, propulsion, guidance and control, and all other installed equipment integral to the launch vehicle as an entity within itself
- the design, development, and production of complete units (i.e., the prototype or operationally configured units which satisfy the requirements of their applicable specification, regardless of end use)
- Sub-elements to the launch vehicle (F.3.2.1 -- F.3.2.7)

Note: ***All effort directly associated with the remaining level 3 WBS elements and the integration, assembly, test and checkout of these elements into the launch vehicle is excluded.***

F.3.2.1 -- Propulsion (Single Stage Only)

The means for generating the launch vehicle into its operational orbit or its intended path.

Includes, for example:

- engine, structure, propellant and fuel, distribution and control of propellant and fuel, starting means, safety devices, and internal environmental control grouped as a functional entity
- design, development, production, and assembly efforts to provide the propulsion subassembly

F.3.2.2 -- Stage I

The launch vehicle stage which provides initial lift-off propulsion for the complete launch vehicle (flyaway) and cargo.

Includes, for example:

- structure, propulsion, controls, instrumentation, and all other installed subsystem equipment integral to Stage 1 as an entity
- design, development, production, and assembly efforts to provide Stage I as an entity

Excludes:

- strap-on units

Note: ***All effort directly associated with the remaining level 3 WBS elements and the integration, assembly, test and checkout of these elements into the launch vehicle is excluded.***

F.3.2.3 -- Stage II..n (As Required)

The second and subsequent launch vehicle stages (if applicable) used to place a space vehicle into its operational environment.

Includes, for example:

- propulsion following separation of the first stage and subsequent stages (if applicable)
- structure, propulsion, controls, instrumentation, separation subsystems, and all other installed subsystem equipment integral to the stage as an entity
- design, development, production, and assembly efforts to provide each individual stage as an entity

Excludes:

- strap-on units

Note: ***All effort directly associated with the remaining level 3 WBS elements and the integration, assembly, test and checkout of these elements into the launch vehicle is excluded.***

F.3.2.4 -- Strap-On Units (As Required)

Solid or liquid propulsion assemblies that provide additional thrust or propellant to assist the launch vehicle in placing a spacecraft into its operational orbit if strap-on units are employed.

Includes, for example:

- complete set of strap-on units -- case, nozzle, igniter, tanks, mounting structure, cordage, etc.
- design, development, production, and assembly efforts to provide the strap-on units as an entity

Note: ***All effort directly associated with the remaining level 3 WBS elements and the integration, assembly, test and checkout of these elements into the launch vehicle is excluded.***

F.3.2.5 -- Shroud (Payload Fairing)

The protective covering and equipment mated to the launch vehicle which protects the cargo (i.e., orbital transfer vehicle or space vehicle/orbital transfer vehicle combination) prior to and during the launch vehicle ascent phase.

Includes, for example:

- structure -- the shroud structure, mechanisms and hinges
- instrumentation -- the hardware and software required to measure the environment and loads being experienced by the shroud during the ascent phase until shroud separation and deployment
- separation subsystem -- the sequencers, ordnance, and other necessary mechanisms to assure a successful shroud separation from the launch vehicle and cargo
- power system -- the necessary generation, storage, and distribution of electrical power and signals, hydraulic power, and any other power required by the shroud

- thermal control systems -- thermal paint, insulation, heat shield tiles, or any other active or passive means necessary to maintain appropriate temperature of the shroud and mission equipment within it

- integration, assembly, test and checkout

Note: ***All effort directly associated with the remaining level 3 WBS elements and the integration, assembly, test and checkout of these elements into the launch vehicle is excluded.***

F.3.2.6 -- Guidance and Control

The means (hardware/software) for generating or receiving guidance intelligence, conditioning the intelligence to produce control signals, and generating appropriate control forces.

Controllers may interface with the structure by actuating moveable aero surfaces or with the propulsion system to produce control reaction forces or may independently produce reaction forces for control.

If the design is such that electronics are packaged into a single rack or housing as an assembly, this rack or housing will be considered part of the guidance and control system.

Includes, for example:

- guidance intelligence system, computer, sensing elements, etc.

Note: ***All effort directly associated with the remaining level 3 WBS elements and the integration, assembly, test and checkout of these elements into the launch vehicle is excluded.***

F.3.2.7 -- Integration, Assembly, Test, and Checkout.

The integration, assembly, test, and checkout element includes all efforts as identified in Appendix H: Work Breakdown Structure Definitions, Common Elements, to provide a complete launch vehicle.

F.3.3 -- Orbital Transfer Vehicle

Any transportation system utilized for placing spacecraft in an operational environment following launch vehicle separation or deployment. Orbital transfer vehicle includes, for example, "upper-stages" and orbital maneuvering vehicles. The orbital transfer vehicle may be single-stage or multiple-stage configuration.

Includes:

- structure, propulsion, guidance and control; all other installed equipment; and all software integral to the vehicle

- design development, and production of complete units (i.e., prototype or operationally configured units which satisfy the requirements of their applicable specifications, regardless of end use)

- Sub-elements to the orbital transfer vehicle -- Propulsion, Stage I, Stage II..n, Strap-On Units, Guidance and Control, Integration, Assembly, Test and Checkout (Sections F.3.3.1 through F.3.3.4)

Note: ***All effort directly associated with the remaining level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the orbital transfer vehicle is excluded.***

F.3.3.1 -- Propulsion (Single Stage Only).

The means for generating the orbital transfer vehicle into its operational orbit.

Includes, for example:

- engine, structure, propellant and fuel, distribution and control of propellant and fuel, starting means, safety devices, and internal environmental control grouped as a functional entity

- design, development, production, and assembly efforts to provide the propulsion structure as an entity

F.3.3.2 -- Stage I

The orbital transfer vehicle stage which provides initial propulsion for the orbital transfer vehicle following separation or deployment from the launch vehicle.

Includes, for example:

- structure, propulsion, controls, instrumentation, separation, and all other installed subsystem equipment integral to Stage 1 as an entity

- design, development, production, and assembly efforts to provide Stage I as an entity

Excludes:

- strap-on units

F.3.3.3 -- Stage II..n (As Required)

The second orbital transfer vehicle stage and subsequent stages (as required) used to place a space vehicle into its operational environment. This stage provides propulsion following separation of the first stage.

Includes, for example:

- structure, propulsion, controls, instrumentation, separation subsystems, and all other installed subsystem equipment integral to the stage as an entity
- design, development, production, and assembly efforts to provide each stage as an entity

Excludes:

- strap-on units

F.3.3.4 -- Strap-On Units (As Required)

The solid or liquid propulsion assemblies that provide additional thrust or propellant to assist the orbital transfer vehicle in placing a space vehicle into its operational orbit if strap-on units are employed.

Includes, for example:

- complete set of strap-on units -- the case, nozzle, igniter, tanks, mounting structure, cordage, etc.
- design, development, production, and assembly efforts to provide the strap-on units as an entity

F.3.3.5 -- Guidance and Control

The means (hardware/software) for generating or receiving guidance intelligence, conditioning the intelligence to produce control signals, and generating appropriate control forces.

Controllers may interface with the structure by actuating moveable aero surfaces or with the propulsion system to produce control reaction forces or may independently produce reaction forces for control.

If the design is such that electronics are packaged into a single rack or housing as an assembly, this rack or housing will be considered part of the guidance and control element.

Includes, for example:

- guidance intelligence system, computer, sensing elements, etc.

F.3.3.6 -- Integration, Assembly, Test, and Checkout

The integration, assembly, test, and checkout element includes all efforts as identified in Appendix H: Work Breakdown Structure Definitions, Common Elements, to provide a complete orbital transfer vehicle.

F.3.4 -- Space Vehicle

The complete vehicle, or group of vehicles placed into space (operational orbit environment).

Includes:

- spacecraft, payload, reentry vehicle and orbit injection/dispenser, and integration, assembly, test, and checkout
- design, development, and production of complete units -- (i.e., prototype or operationally configured units which satisfy the requirements of their applicable specifications, regardless of end use)
- sub-elements to the space vehicle -- Spacecraft, Payload I..n, Reentry Vehicle, Orbit Injector/Dispenser, Integration, Assembly, Test and Control (F.3.4.1 -- F.3.4.5)

Note: ***All effort directly associated with the remaining level 3 WBS elements and the integration, assembly, test and checkout of these elements into the space vehicle is excluded.***

F.3.4.1 -- Spacecraft

The principal operating space vehicle which serves as a housing or platform for carrying a payload and other mission-oriented equipments in space.

Includes, for example:

- structure, power, attitude determination and control, and other equipments characteristic of spacecraft
- all design, development, production, and assembly efforts to provide the spacecraft as an entity

F.3.4.2 -- Payload

The equipment provided for special purposes in addition to the normal equipment integral to the spacecraft or reentry vehicle.

Includes, for example:

- experimental equipment placed on board the vehicle and flight crew equipment (space suits, life support, and safety equipment)
- communications, displays and instrumentation, telemetry equipment and other equipments specifically to collect data for future planning and projection purposes

Note: ***All effort directly associated with the remaining level 3 WBS elements and the integration, assembly, test and checkout of these elements into the space vehicle is excluded.***

F.3.4.3 -- Reentry Vehicle

The principal operating vehicle specifically designed to safely reenter the atmosphere in order to land a payload (experimental equipment or crew).

Includes, for example:

- navigation and guidance, power supply, command and control, attitude control, environmental control, propulsion, and other equipments homogeneous to the reentry vehicle
- all design, development, production, and assembly efforts to provide the reentry vehicle as an entity

Note: ***All effort directly associated with the remaining level 3 WBS elements and the integration, assembly, test and checkout of these elements into the space vehicle is excluded.***

F.3.4.4 -- Orbit Injector/Dispenser

The function of placing orbiting objects in the planned orbital path.

Includes, for example:

- structure, propulsion, instrumentation and stage interface, separation subsystem, and other equipment necessary for integration with other level 3 elements

Note: ***All effort directly associated with the remaining level 3 WBS elements and the integration, assembly, test and checkout of these elements into the space vehicle is excluded.***

F.3.4.5 -- Integration, Assembly, Test, and Checkout

The integration, assembly, test, and checkout element includes all efforts as identified in Appendix H: Work Breakdown Structure Definitions, Common Elements, to provide a complete space vehicle.

F.3.5 -- Ground Command, Control, Communications, and Mission Equipment

The ground hardware/software equipment used for communicating between control and tracking facilities, monitoring the health and status of space vehicles, commanding the space vehicle's hardware, and adjusting the space vehicle's orbit as required for space vehicle health or mission purpose.

Two configurations for the ground command, control, communications and mission equipment are the parabolic dish-based antenna system and the phased array-based antenna system.

If a ground site has multiple antenna configurations, each will have its own separate command and control equipment, communications equipment, data processing equipment and test equipment.

Includes:

- the design, development, and production of complete units -- (i.e., prototype or operationally configured units which satisfy the requirements of their applicable specifications, regardless of end use)
- sub-elements to the ground command, control, communications, and mission equipment (F.3.5.1 -- F.3.5.6)

F.3.5.1 -- Sensor I..n (As Required)

Those hardware and software elements/components which comprise the sensor system.

Includes, for example:

- antenna, platform/pedestal, radome, transmission equipment, reception equipment, and other sensor subsystems
- design, development, production, and assembly efforts to provide each sensor as an entity

F.3.5.2 -- Telemetry, Tracking and Control

The hardware/software elements that facilitate launch decisions and command and control of the aerospace vehicle.

Includes, for example:

- supplementary means for guidance of those aerospace vehicles not having completely self-contained guidance and control and means to command destruct
- control and check-out consoles, data displays, and mission records

F.3.5.3 -- External Communications

The hardware and software components that allow the ground station to communicate with any external data link or source like telephone (analog) lines, digital data lines, nonsatellite radio receivers. While the terrestrial data lines may connect to radio of other satellite communications stations, the external communications subsystem ends where these links physically connect to the secure communications, modulation/demodulation (modem) or coder/decoder equipment.

F.3.5.4 -- Data Processing Equipment

The hardware and software components that provide the activities and means to condition data generated at the launch site or aboard the space vehicle, or data received from associated systems to accommodate the needs of command and control or mission data processing.

Includes, for example:

- central processing unit (computer), peripheral equipment, and the software required to operate the data processing equipment.

F.3.5.5 -- Launch Equipment

The means to launch the aerospace vehicle from stationary sites.

Includes, for example:

- storage facilities and checkout stations for readiness verification when these are integral to the launcher
- safety and protective elements when these are not integral to the launch platform or facilities

F.3.5.6 -- Auxiliary Equipment

The general purpose/multi-usage ground equipment utilized to support the various operational capabilities of the command and launch equipments.

Includes, for example:

- power generators, power distribution systems, environmental control, cabling, malfunction detection, fire prevention, security systems, and other common-usage items not applicable to specific elements of the ground based equipment

F.3.6 -- Flight Support Operations and Services

Mate/checkout/launch; mission control; tracking; and command, control and communications (C^3); recovery operations and services; and launch site maintenance/refurbishment. This element supports the launch vehicle, orbital transfer vehicle, and/or space vehicle during an operational mission.

Sub-elements to the flight operations and services (F.3.6.1 -- F.3.6.5).

F.3.6.1 -- Mate/Checkout/Launch

The preflight operations and services subsequent to production and/or storage, and the actual launch of the complete system and payload.

Includes, for example:

- materials to conduct equipment receiving and checkout at launch site, preflight assembly and checkout, pre/post flight data reduction and analysis, and any prelaunch flight control/mission control planning

F.3.6.2 -- Mission Control

The personnel and materiel required to operate individual mission control centers and to perform ground command and control with the space vehicles.

Includes, for example:

- mission control centers such as Constellation Command Center, Battle Management/Command Control Center (BM/C^3), Space Asset Support System Control Center, and Space Transportation Control Center

Excludes:

- tracking and communications centers (these are included in WBS element F.3.6.3)

F.3.6.3 -- Tracking and C^3

The personnel and materiel required to perform the functions of telemetry, tracking, controlling, and data retrieval for the mission control systems.

Includes, for example:

- mission control systems, on the ground or in space, including Satellite Control Facility; Remote Tracking Station; Tracking, Data, Relay Satellite System; and other ground/space tracking systems

Excludes:

- initial acquisition of tracking and C^3 (acquisition of these systems is included in WBS element F.3.6.4)

F.3.6.4 -- Recovery Operations and Services

The contractor effort and materiel necessary to effect recovery of the space vehicle or other mission equipment.

Includes:

- the launch site recovery forces, reentry site recovery forces, logistics support to recovery forces, logistics support to the recovery operations, communications, and transportation of recovered equipment to assigned facilities

F.3.6.5 -- Launch Site Maintenance/Refurbishment

The organization, maintenance, and management of launch vehicle facilities and mission equipment, and support at the launch base.

Includes, for example:

- requirements to clean up and refurbish each launch site after each launch

F.3.7 -- Storage

Those costs of holding portions of the space system while awaiting use of the system being stored, prepared for storage, or recovered from storage. Periods of holding result from schedule changes and/or technological problems exogenous to the portion of the space system.

Includes:

- Sub-elements to storage (F.3.7.1 -- F.3.7.3)

F.3.7.1 -- Planning and Preparation

The planning and preparation costs for storage of all systems/subsystems associated with the launch vehicle, orbital transfer vehicle, and space vehicle equipment.

Includes, for example:

- generation of any storage or maintenance instructions and documents necessary for repairable systems or subsystems

F.3.7.2 -- Storage

The cost incurred while the systems or subsystems of the launch vehicle, orbital transfer vehicle, and space vehicle equipment are in storage.

F.3.7.3 -- Transfer and Transportation

The transfer and storage costs incurred when the systems/subsystems of the launch vehicle, orbital transfer vehicle, and space vehicle equipment are moved from one location to another.

Includes, for example:

- costs of relocation necessitated by mission requirements

F.3.8 -- WBS Common Elements

Definitions for common WBS elements applicable to the space system and all other defense materiel items are in Appendix H: Work Breakdown Structure Definitions, Common Elements.

Next Section